ANNEX H

Methodology for Estimating Emissions from International Bunker Fuels used by the U.S. Military

Bunker fuel emissions estimates for the Department of Defense (DoD) were developed using data generated by the Defense Energy Support Center for aviation and naval fuels. The Defense Energy Support Center (DESC) of the Defense Logistics Agency (DLA) prepared a special report based on data in the Defense Fuels Automated Management System (DFAMS). DFAMS contains data for 1995 through 1999, but the data set was not complete for years prior to 1995. Fuel quantities for 1990 to 1994 were estimated based on a back-calculation of the 1995 DFAMS values using DLA aviation and marine fuel procurement data.

Step 1: Omit Extra-Territorial Fuel Deliveries

Beginning with the complete DFAMS data set for each year, the first step in the development of DoD related emissions from international bunker fuels was to identify data that would be representative of international bunker fuel consumption as that term is defined by decisions of the UNFCCC (i.e., fuel sold to a vessel, aircraft, or installation within the United States or its territories and used in international maritime or aviation transport). Therefore, fuel data was categorized by the location of fuel delivery in order to identify and omit all extra-territorial fuel transactions/deliveries (i.e., sales abroad). Table H-1 displays the fuels that remain at the completion of Step 1, summarized by fuel type.

Step 2: Omit Fuel Transactions Received by Military Services that are not Considered to be International Bunker Fuels

Next, fuel transaction/delivery records were sorted by military Service. The following assumptions were made regarding bunker fuel use by Service, leaving only the Navy and Air Force as users of military international bunker fuels.

- Only fuel delivered to a ship, aircraft, or installation in the United States can be a potential international bunker fuel. Fuel consumed in international aviation or marine transport should be included in the bunker fuel estimate of the country where the ship or aircraft was fueled. Fuel consumed entirely within a country's borders is not bunker fuel.
- Based on discussions with the Army staff, only an extremely small percentage of Army aviation emissions, and none of its watercraft emissions, qualified as bunker fuel emissions. The magnitude of these emissions was judged to be insignificant when compared to Air Force and Navy emissions. Based on this, Army bunker fuel emissions are assumed to be zero.
- Marine Corps aircraft operating while embarked consume fuel reported as delivered to the Navy. Bunker fuel emissions from embarked Marine Corps aircraft are reported in the Navy bunker fuel estimates. Bunker fuel emissions from other Marine Corps operations and training are assumed to be zero.
- Bunker fuel emissions from other DoD and non-DoD activities (i.e., other federal agencies) that purchase fuel from DESC are assumed to be zero.

Step 3: Omit Land-Based Fuels

Navy and Air Force land-based fuel consumption (i.e., fuel not used by ships or aircraft) were also omitted. The remaining fuels, listed below, were potential military international bunker fuels.

- Marine: naval distillate fuel (F76) and marine gas oil (MGO).
- Aviation: jet fuels (JP8, JP5, JAA, and JA1).

Step 4: Determine Bunker Fuel Percentages

Next it was necessary to determine what percent of the marine and aviation fuels were used as international bunker fuels. Military aviation bunkers include international operations (i.e., sorties that originate in the United States and terminate in a foreign country), operations conducted from naval vessels at sea, and operations conducted from U.S. installations principally over international water in direct support of military operations at sea (e.g., anti-submarine warfare flights). For the Air Force, a bunker fuel weighted average was calculated based on flying hours by major command. International flights were weighted by an adjustment factor to reflect the fact that they typically last longer than domestic flights. In addition, a fuel use correction factor was used to account for the fact that transport aircraft burn more fuel per hour of flight than most tactical aircraft. The Air Force bunker fuel percentage was determined to be 13.2 percent. This percentage was multiplied by total annual Air Force aviation fuel delivered for U.S. activities, producing an estimate for international bunker fuel consumed by the U.S. Air Force. The naval aviation bunker fuel percentage of total fuel was calculated using flying hour data from *Chief of Naval Operations Flying Hour Projection System Budget Analysis Report for FY 1998*, and estimates of bunker fuel percent of flights provided by the fleet. The naval aviation bunker fuel percentage, determined to be 40.4 percent, was multiplied by total annual Navy aviation fuel delivered for U.S. activities, yielding total Navy aviation bunker fuel consumed.

For marine bunkers, fuels consumed while ships were underway were assumed to be bunker fuels. The Navy reported that 87 percent of vessel operations were underway, while the remaining 13 percent of operations occurred in port (i.e., pierside). Therefore, the Navy maritime bunker fuel percentage was determined to be 87 percent. Table H-2 and Table H-3 display DoD bunker fuel totals for the Navy and Air Force.

Step 5: Calculate Emissions from Military International Bunker Fuels

Bunker fuel totals were multiplied by appropriate emission factors to determine greenhouse gas emissions (see Table H-4 and Table H-5.

The rows labeled 'U.S. Military' and 'U.S. Military Naval Fuels' within Table 2-36 and Table 2-37 in the Energy Chapter were based on the international bunker fuel totals provided in Table H-2 and Table H-3, below. Total CO_2 emissions from military bunker fuels are presented in Table H-6. Carbon dioxide emissions from aviation bunkers and distillate marine bunkers presented in Table 2-7 are the total of military plus civil aviation and civil marine bunker fuels, respectively. The military component of each total is based on fuels tallied in Table H-2 and Table H-3. Carbon dioxide emissions from military vehicles (e.g., ships, aircraft, and land-based vehicles) presented in Table 2-7 of the Inventory were calculated by subtracting total aviation bunker fuel in Table H-2 from the aviation subtotal in Table H-1. Motor gasoline totals presented in Table H-1 were estimated using data provided by the military Services.

Table H-1: Transportation Fuels from Domestic Fuel Deliveries[a] (Thousand Gallons)

Vehicle Type/Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Aviation	**4,598,449**	**4,562,840**	**3,734,487**	**3,610,849**	**3,246,234**	**3,099,929**	**2,941,907**	**2,697,277**	**2,764,760**	**2,670,285**
Total Jet Fuels	4,598,420	4,562,811	3,734,464	3,610,826	3,246,213	3,099,910	2,941,898	2,697,273	2,764,740	2,670,273
JP8	285,750	283,537	234,460	989,381	1,598,070	2,182,803	2,253,149	2,083,641	2,145,891	2,101,518
JP5	1,025,357	1,017,417	832,712	805,143	723,841	691,219	615,831	552,771	515,556	505,502
Other Jet Fuels	3,287,313	3,261,857	2,667,292	1,816,302	924,302	225,888	72,918	60,860	103,294	63,252
Aviation Gasoline	29	28	23	22	20	19	9	4	19	12
Marine	**686,804**	**632,606**	**646,178**	**589,374**	**478,592**	**438,906**	**487,480**	**630,895**	**659,526**	**592,161**
Middle Distillate (MGO)	0	0	0	0	0	0	38,524	47,483	51,136	49,223
Naval Distillate (F76)	686,804	632,606	646,178	589,374	478,592	438,906	448,956	583,412	608,389	542,938
Other[c]	**717,113**	**590,408**	**491,679**	**415,097**	**356,062**	**310,948**	**276,900**	**251,664**	**233,468**	**220,918**
Diesel[b,c]	93,044	97,878	102,964	108,314	113,942	119,862	126,090	132,641	139,533	146,782
Gasoline[b,c]	624,069	492,529	388,715	306,783	242,120	191,087	150,810	119,023	93,935	74,136
Total (Including Bunkers)	**6,002,366**	**5,785,853**	**4,872,344**	**4,615,320**	**4,080,887**	**3,849,783**	**3,706,287**	**3,579,836**	**3,657,753**	**3,483,364**

Note: Totals may not sum due to independent rounding.

[a] Includes fuel consumption in United States and U.S. Territories.

[b] Annual growth factors used for interpolation and extrapolation of 1990 and 1996 data for other diesel and gasoline were 5.2 percent and -21.1 percent, respectively.

[c] 1999 domestic fuel deliveries for land-based transportation fuels (i.e., diesel and gasoline) were estimated. Data on these fuels is being collected from the military Services. Revised figures based on Service data will be provided in October 2000.

Table H-2: Total U.S. Military Aviation Bunker Fuel (Million Gallons)

Fuel Type/Service	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
JP8	**56.74**	**56.30**	**46.40**	**145.33**	**223.99**	**300.40**	**308.81**	**292.01**	**306.39**	**301.35**
Navy	56.74	56.30	46.08	44.56	40.06	38.25	39.84	46.92	53.81	55.46
Air Force	+	+	0.32	100.77	183.93	262.15	268.97	245.09	252.59	245.89
JP5	**370.53**	**367.66**	**300.92**	**290.95**	**261.57**	**249.78**	**219.40**	**194.16**	**184.38**	**175.37**
Navy	365.29	362.46	296.66	286.83	257.87	246.25	216.09	191.15	181.36	170.59
Air Force	5.25	5.21	4.26	4.12	3.70	3.54	3.31	3.01	3.02	4.77
JP4	**420.77**	**417.52**	**341.40**	**229.64**	**113.11**	**21.50**	**1.05**	**0.05**	**0.03**	**0.02**
Navy	0.02	0.02	0.02	0.02	0.01	0.01	0.00	0.00	0.00	0.00
Air Force	420.75	417.50	341.39	229.62	113.10	21.49	1.05	0.05	0.03	0.02
JAA	**13.70**	**13.60**	**11.13**	**10.76**	**9.67**	**9.24**	**10.27**	**9.42**	**10.84**	**10.78**
Navy	8.45	8.39	6.86	6.64	5.97	5.70	6.58	5.88	6.63	6.32
Air Force	5.25	5.21	4.27	4.12	3.71	3.54	3.69	3.54	4.21	4.47
JA1	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**0.01**	**+**
Navy	+	+	+	+	+	+	+	+	+	+
Air Force	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**0.01**	**+**
JAB	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**	**+**
Navy	+	+	+	+	+	+	+	+	+	+
Air Force	+	+	+	+	+	+	+	+	+	+
Navy Subtotal	**430.50**	**427.17**	**349.62**	**338.04**	**303.91**	**290.21**	**262.51**	**243.95**	**241.80**	**232.37**
Air Force Subtotal	**431.25**	**427.91**	**350.23**	**338.63**	**304.44**	**290.72**	**277.02**	**251.70**	**259.86**	**255.14**
Total	**861.75**	**855.08**	**699.85**	**676.68**	**608.35**	**580.93**	**539.53**	**495.65**	**501.66**	**487.52**

+ Does not exceed 0.005 million gallons.
Note: Totals may not sum due to independent rounding.

Table H-3: Total U.S. DoD Maritime Bunker Fuel (Million Gallons)

Marine Distillates	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Navy - MGO	+	+	+	+	+	+	30.34	35.57	31.88	39.74
Navy - F76	522.37	481.15	491.47	448.27	364.01	333.82	331.88	441.65	474.23	465.97
Total	**522.37**	**481.15**	**491.47**	**448.27**	**364.01**	**333.82**	**362.22**	**477.22**	**506.11**	**505.71**

+ Does not exceed 0.005 million gallons.
Note: Totals may not sum due to independent rounding.

Table H-4: Aviation and Marine Carbon Contents (Tg Carbon/Qbtu) and Fraction Oxidized (%)

Mode (Fuel)	Carbon Content Coefficient	Fraction Oxidized
Aviation (Jet Fuel)	variable	99%
Marine (Distillate)	19.95	99%

Table H-5: Annual Variable Carbon Content Coefficient for Jet Fuel (Tg Carbon/Qbtu)

Fuel	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Jet Fuel	19.40	19.40	19.39	19.37	19.35	19.34	19.33	19.33	19.33	19.33

Table H-6: Total U.S. DoD CO_2 Emissions from Bunker Fuels (Tg CO_2 Eq.)

Mode	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Aviation	8.3	8.2	6.7	6.5	5.8	5.6	5.2	4.8	4.8	4.7
Marine	5.2	4.8	4.9	4.5	3.7	3.4	3.6	4.8	5.1	5.1
Total	**13.5**	**13.1**	**11.7**	**11.0**	**9.5**	**8.9**	**8.8**	**9.5**	**9.9**	**9.8**

Note: Totals may not sum due to independent rounding.